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Green Manufacturing for the Win! A Look at the United States versus the World

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Abstract

This paper looks into the history of manufacturing in the United States of America (U.S.A.) and compares the evolution of manufacturing systems of the U.S.A. to other industrialized and industrializing nations. It explores the ground-breaking technologies developed throughout the history of modern manufacturing and how government regulations have helped and hindered in certain sectors. This paper also looks at the way companies are using green technologies and ideas to meet regulations and help curb carbon emissions for a healthier planet.

The second idea behind this paper is to show the economic impact of green technology in the manufacturing industry and how communities and certain regions of the world are impacted when this type of technology is utilized or ignored. Specific ideas that are explored include the creation of the Environmental Protection Agency (EPA), the Clean Water Act (CWA), the Paris Climate Agreement (PCA), and several other actions that have been taken in recent decades. There is a comparison of past national government administrations and current national government administrations to show economic and environmental impacts from policy creation.

This paper also looks at the future of green manufacturing and how it will effect economic outcomes around the world including local regional communities in the U.S.A. It will provide details on new technologies being developed by entrepreneurs from around the world and the insight they and other experts believe the benefits of those technologies will be.

Scientific evidence is provided along with graphs and charts showing the impact of manufacturing on the environment and the economy from the Industrial Revolution to modern technologies. This type of information is the basis of how manufacturers make decisions to meet regulations and make good faith efforts toward local communities.

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I. Introduction

Manufacturing has become an economic powerhouse both within the U.S.A. and around the globe since the first Industrial Revolution began in the latter part of the 18th century in Britain (Industrial Revolution, 2018). It is an industry that has evolved throughout the history of the world and has had many global leaders with the U.S.A. and China having the strongest annual outputs in the most current years (West & Lansing, 2018). It is an industry that has gone through many forms of regulations to help curb pollution to water and air. There have also been protections put into place to end slavery, prevent the exploitation of young workers, and help families have a better standard of living. It is an industry that will continue to evolve in order to keep families in an acceptable standard of living and slow the effects of climate change on the Earth.

II. The Industrial Revolution and Unions

According to the New World Encyclopedia (2018), the first idea of industries making changes can be traced back to the early parts of the 17th century in the United Kingdom (U.K.) after the Act of Union. This was in large part because of the stable banking, strong, enforced laws, and a developing road system within the U.K. between England and Scotland. Textile industries, developing iron-making techniques, and the increasing use of coal is what started the revolution. This led to better technological developments in other areas such as canals, better roads, steam power, and powered machinery (Industrial Revolution, 2018). As technology and

manufacturing improved, it began to spread into other parts of Europe and eventually into the U.S.A.

The textile industry saw the invention of the spinning jenny by Englishman James Hargreaves in the late 18th century which revolutionized textile manufacturing in England (Mahoney, 2017). The Industrial Revolution began in the U.S.A. in large part due to the invention of the cotton gin by Eli Whitney in the 1790s. This invention cut labor for processing cotton down exponentially, and American cotton production rose nearly twenty-seven times the amount being produced in a matter of fifty years, from 1800-1850. Slavery had been in decline during this time but was becoming a larger part of the southern states production of cotton to keep up with demand in England (Mahoney, 2017). During these decades of prosperity and growth, many of the new technologies, including the development of steamboats, led to the creation of canals near major bodies of water. Steamboats could also go against the current of strong rivers, making it easier to ship goods to the northern states from the southern states (Mahoney, 2017).

Another major invention in its infancy during the same time period was the railroad system. Railways have advantages over rivers and canals because a railroad can be put almost anywhere, and trains can travel in most weather conditions. The first transcontinental railroad was built in the 1860s and connected the east to the west allowing goods, such as crops and mined ores, to be quickly transported. Railroads helped to build the American empire and create vast wealth for many investors and company owners (Mahoney, 2017).

With the quickly expanding manufacturing sector in the U.S.A. came a growing concern for the welfare of workers. Labor unions began to form prior to the American Civil War to attain safer work environments and fair wages. These unions began to understand that there was

strength in numbers and the American Federation of Labor (AFL) was formed in 1886 (Aldrich, 1898). After the Great Depression hit workers in the labor movement, a new group began to form for mass production industries. This was a split from trying to protect every worker in every union with the same protections to organizing protections for larger industries such as coal, rubber, steel, and automobiles. Thus, the Committee for Industrial Organization (CIO) was established in 1938. More than twelve million workers belonged to unions by the end of World War II (WWII), and collective bargaining had become a strong tool for unions (History.com Editors, 2009). The AFL and CIO merged to form the AFL-CIO on December 5, 1955 with many of the same principles for fair wages and equal opportunities (Tortora, 216).

Before the CIO was officially created, President Franklin D. Roosevelt (FDR) authorized a set of laws passed called the New Deal in order to boost economic growth through job creation. "He also authorized $500 million in direct grants through the Federal Emergency Relief Act (FERA). This money went directly to states to infuse relief agencies with the much-needed resources to help the nearly fifteen million unemployed" (Corbett, Janssen, Lund, Pfannestiel, & Vickery, 2017). Below is a chart retrieved from a U.S. history textbook of the major legislations passed, years enacted, and a brief description of each.

New Deal Legislation	**Years Enacted**	**Brief Description**
Agricultural Adjustment Administration	1933–1935	Farm program designed to raise process by curtailing production
Civil Works Administration	1933–1934	Temporary job relief program
Civilian Conservation Corps	1933–1942	Employed young men to work in rural areas
Farm Credit Administration	1933-today	Low interest mortgages for farm owners
Federal Deposit Insurance Corporation	1933–today	Insure private bank deposits
Federal Emergency Relief Act	1933	Direct monetary relief to poor unemployed Americans
Glass-Steagall Act	1933	Regulate investment banking

Homeowners Loan Corporation	1933–1951	Government mortgages that allowed people to keep their homes
Indian Reorganization Act	1933	Abandoned federal policy of assimilation
National Recovery Administration	1933–1935	Industries agree to codes of fair practice to set price, wage, production levels
Public Works Administration	1933–1938	Large public works projects
Resettlement Administration	1933–1935	Resettles poor tenant farmers
Securities Act of 1933	1933–today	Created SEC; regulates stock transactions
Tennessee Valley Authority	1933–today	Regional development program; brought electrification to the valley

(Corbett, Janssen, Lund, Pfannestiel, & Vickery, 2017)

The Civilian Conservation Corps (CCC) listed in the above chart played a major role in rural areas. The government paid young men between the ages of fourteen and twenty-four to plant trees, fight forest fires, and do other public works of conservation and infrastructure. This program would employee nearly a quarter million men in the first two months of its creation (Corbett, Janssen, Lund, Pfannestiel, & Vickery, 2017). Trees are a major part of capturing carbon from the atmosphere and provide all animals with clean oxygen to breathe. The CCC was providing cleaner air for the Earth and probably did not realize the true impact of their work for future generations. In October of 1938, only a few years after the legislation of the New Deal, the Fair Labor Standards Act became effective. This hard-fought law created a federal minimum hourly wage, a maximum forty-four hour work week, and banned harsh child labor (Grossman). Workers were beginning to see improvements in quality of life while jobs in the private sector were being revived. These laws passed during FDR's administration were the first of their kind with major impacts to the manufacturing industry.

III. Government Environmental Actions

In 1948, the Federal Water Pollution Control Act became the first law in the U.S.A. to address pollution in water, according to the EPA. The creation of the EPA in 1970 by the Nixon

administration is perhaps the largest national attempt to limit the amount of pollution that companies were allowed to emit either directly through regulating the types and amounts of waste or indirectly by setting new standards for automobiles. The EPA government website (2018) tells the origins with a few examples of such waste with the following:

> "The American conversation about protecting the environment began in the 1960s. Rachel Carson had published her attack on the indiscriminate use of pesticides, *Silent Spring*, in 1962. Concern about air and water pollution had spread in the wake of disasters. An offshore oil rig in California fouled beaches with millions of gallons of spilled oil. Near Cleveland, Ohio, the Cuyahoga River, choking with chemical contaminants, had spontaneously burst into flames. Astronauts had begun photographing the Earth from space, heightening awareness that the Earth's resources are finite."

The Clean Air Act (CAA) of 1970 and the CWA in 1972 became two more major accomplishments by the Nixon administration in the fight against pollution. The EPA was now authorized to create National Ambient Air Quality Standards (NAAQS) "to protect public health and public welfare and to regulate emissions of hazardous air pollutants" (www.epa.gov). These standards for the CAA were amended in 1977 and 1990 to give certain areas of the country more time to meet the NAAQS. The CWA "establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters" (www.epa.gov). Companies are now required to obtain permits to make controlled dumps into the nation's waterways.

More recent changes to the CWA include an Obama administration order "to limit pollution in the nation's rivers, lakes, streams and wetlands" (Davenport, 2015). The idea was to limit pollution that had potential to enter into major waterways and eventually into America's

drinking water (Davenport, 2015). This rule was seen as being detrimental to economic growth by many politicians and businesses, but it was thoroughly researched by the EPA and the Army Corps of Engineers. "The agency has held more than 400 meetings about it with outside groups and read more than one million public comments as it wrote the final language" (Davenport, 2015). It was considered a victory for environmental advocates. But the changes did not last very long with the Trump administration announcing the repeal of these regulations in September, 2019 (Davenport & Friedman, 2019). This latest decision is seen as a victory for farmers and other landowners and as an ongoing battle between environmentalists and the Trump administration. The Trump administration has been successful in rolling back fifty-three environmental rules with many more in process, most of which are facing legal challenges (Popovich, Albeck-Ripka, & Pierre-Louis, 2019).

The European Union (EU), with the European Commission (EC), was also taking pollution as a political concern in the 1970s. The World Health Organization (WHO), which was established in 1948, developed the first edition of the "Air Quality Guidelines for Europe" in 1987 (Theakston, 2000). This guideline did not set standards for pollution but instead set parameters to study twenty-eight chemical air contaminants and make those findings available to the public. With these findings, the WHO began to set standards for acceptable amounts of human exposure to these contaminants in the atmosphere (Theakston, 2000). The standards have been set since the mid-1990s and are regularly updated based on the research and newly found evidence of health risks to humans. Current reports on the air quality in Europe can be found from the European Environment Agency (EEA) annually with 2018 being the latest published report. These reports are available online and free print copies can be requested. Below is a table

from the 2018 report showing current standards for air quality (Guerreiro, Ortiz, Leeuw, Viana, & Colette, 2018).

Table 1.1 Air quality standards for the protection of health, as given in the EU Ambient Air Quality Directives

Pollutant	Averaging period	Legal nature and concentration	Comments
PM_{10}	1 day	Limit value: 50 µg/m³	Not to be exceeded on more than 35 days per year
	Calendar year	Limit value: 40 µg/m³	
$PM_{2.5}$	Calendar year	Limit value: 25 µg/m³	
		Exposure concentration obligation: 20 µg/m³	Average Exposure Indicator (AEI) (a) in 2015 (2013-2015 average)
		National Exposure reduction target: 0-20 % reduction in exposure	AEI (a) in 2020, the percentage reduction depends on the initial AEI
O_3	Maximum daily 8-hour mean	Target value: 120 µg/m³	Not to be exceeded on more than 25 days/year, averaged over 3 years (b)
		Long-term objective: 120 µg/m³	
	1 hour	Information threshold: 180 µg/m³	
		Alert threshold: 240 µg/m³	
NO_2	1 hour	Limit value: 200 µg/m³	Not to be exceeded on more than 18 hours per year
		Alert threshold: 400 µg/m³	To be measured over 3 consecutive hours over 100 km² or an entire zone
	Calendar year	Limit value: 40 µg/m³	
BaP	Calendar year	Target value: 1 ng/m³	Measured as content in PM_{10}
SO_2	1 hour	Limit value: 350 µg/m³	Not to be exceeded on more than 24 hours per year
		Alert threshold: 500 µg/m³	To be measured over 3 consecutive hours over 100 km² or an entire zone
	1 day	Limit value: 125 µg/m³	Not to be exceeded on more than 3 days per year
CO	Maximum daily 8-hour mean	Limit value: 10 mg/m³	
C_6H_6	Calendar year	Limit value: 5 µg/m³	
Pb	Calendar year	Limit value: 0.5 µg/m³	Measured as content in PM_{10}
As	Calendar year	Target value: 6 ng/m³	Measured as content in PM_{10}
Cd	Calendar year	Target value: 5 ng/m³	Measured as content in PM_{10}
Ni	Calendar year	Target value: 20 ng/m³	Measured as content in PM_{10}

Notes: (a) AEI: based upon measurements in urban background locations established for this purpose by the Member States, assessed as a 3-year running annual mean.

(b) In the context of this report, only the maximum daily 8-hour means in 2016 are considered, so no average over the period 2014-2016 is presented.

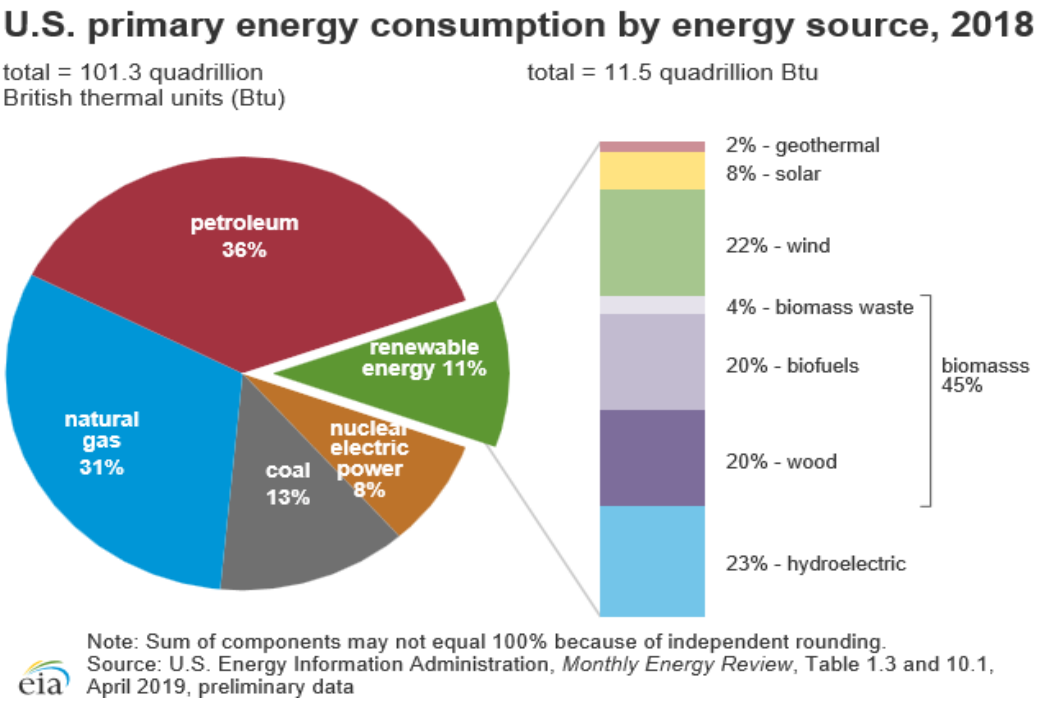
Sources: EU, 2004, 2008.

In April, 2019, London, England launched the Ultra-Low Emission Zone (ULEZ) because of "an increase in children suffering chronic illness and lung damage from air pollutants" (Zialcita, 2019). A "toxicity charge" had been announced in 2017 to only be implemented on older model vehicles with higher than standard emission rates. The ULEZ has seen a decrease in road pollution of about one third and nearly 13,500 fewer vehicles are being driven in the ULEZ daily. There is a daily charge of around fifteen dollars for any vehicle wishing to drive in the city during the day. This money goes to improving the transportation infrastructure. Although there is pushback from affected businesses and citizens, the mayor of London plans to expand the ULEZ in 2021 well beyond its current area (Zialcita, 2019). Paris, France has begun a policy banning nearly all traffic in the city center on the first Sunday of every month (Coffey, 2018). There are exceptions for religious services, repairmen, and caretakers, but anyone who does drive has to stay to a lower speed limit. Anyone not driving can walk, rollerblade, and ride bikes and scooters freely in the city center (Coffey, 2018). This is a policy that also helps keep traffic away from highly populated areas and reduces emissions for cleaner air.

IV. Energy Consumption Around the World

Energy consumption around the world has taken many forward thinking ideas and turned them into industrial realities. According to the U.S. Energy Information Administration (EIA) (2019), the most current data on energy production in the U.S.A. shows that only about eleven percent is produced from renewable sources. The three most used renewable sources are from wind, biomasses, and hydroelectric. Around eighty percent of the total energy consumption is from fossil fuels such as petroleum, natural gas, and coal. Solar energy is under one percent of

total energy consumption in the U.S.A., but is the most likely to have the greatest impact on the future of energy consumption with the growing number of solar fields being developed.



(https://www.eia.gov/energyexplained/us-energy-facts/)

The photovoltaic (PV) effect was first observed during the Industrial Revolution by a French physicist named Alexandre Edmond Becquerellar in 1839 (Sabas, 2016). The modern photovoltaic cell was invented in the 1950s, but was mostly used by the government for military use and space exploration because of the high cost associated with the developing technology (Sabas, 2016). The first time the government tried to make solar the path forward for energy was in the 1970's during the energy crisis. Massive oil shortages led to high energy costs. "Congress passed the 'Solar Energy Research, Development and Demonstration Act of 1974' to create the Solar Energy Coordination and Management Project, an organization designed to direct agencies like NASA, the National Science Foundation, and the Department of Housing and Urban Development to improve solar energy technology and use it to heat and cool government-owned

buildings" (Sabas, 2016). The Energy Research and Development Administration (ERDA) began to install solar energy sources in schools, commercial buildings, and "built the largest solar installation in the world in New Mexico" (Sabas, 2016). All of this did not come from an environmental concern, but an economic one with President Carter calling the energy crisis the "moral equivalent of war." During the Carter administration, the Department of Energy (DOE) Organization Act, the Public Utilities Regulatory Policies Act, the Energy Tax Act, and the Solar, Photovoltaic Energy Research, Development, and Demonstration Act all became law in order to push renewable energy sources to limit the impact of the fossil fuel shortages (Sabas, 2016). President Carter was also able to put solar panels on the White House in 1979 to try to "generate interest among Americans" (Sabas, 2016). The laws created a major change in how Americans look at energy sources and how the government researches renewable energy.

President George W. Bush also passed legislation for more renewable energy sources with the Energy Policy Act of 2005 (EPAct) (Sabas, 2016). The reasoning was again based on the economic impact of high fossil fuel prices and "the rising dependence on foreign oil" (Sabas, 2016). This policy gave tax incentives for residential installations of solar panels. These incentives were scheduled to expire in 2007, but the Tax Relief and Health Care Act of 2006 extended the incentives to 2008. The expiration was again extended through 2016 during the financial crisis with the passing of the Emergency Economic Stabilization Act of 2008, better known as the "bailout" (Sabas, 2019). The American Recovery and Reinvestment Act of 2009, better known as the federal stimulus, was a major investment made during President Obama's administration giving companies large cash grants for creating solar energy systems (Sabas, 2019).

Solar energy is the easiest way for any person concerned about a carbon footprint to use since the sun shines on every part of the planet Earth where people live. Areas in the Northern and Southern Hemispheres would have highly impactful summer seasons when the sun stays out for much longer periods of time. Those living on or near the Equator would always have good seasons since the amount of sun and the seasons do not take as drastic of a change as they do farther north or south. The DOE website (2018) gives the statistic that an hour and a half of sunlight hitting the surface of the earth can produce enough energy for a full year of consumption for the entire world. Private residential households and businesses are utilizing the sun in order to offset energy costs. Utility companies are beginning to build solar power plants to become cleaner energy providers to their customers.

A local example of a utility company making this change comes from Troy, Indiana. The electric provider Vectren announced a plan to build a solar field consisting of 150,000 solar panels on three hundred acres of land. These panels will follow the sun throughout the day to utilize the energy being created. The economic impact of this project will bring green energy to more than 11,000 households and provide two hundred and fifty jobs during construction (Edmonson, 2018).

In the U.S.A., California currently has the highest percent of its power coming from solar energy at around seventeen percent. The solar industry also employees more than 86,000 people in the state (Frangoul, 2018). California is home to some of the U.S.A.'s largest maker of solar panels with eight manufacturers (EnergySage, 2019). The largest solar site in the world is in Noor Abu Dhabi. It was only recently completed with power being generated since the end of June, 2019. The project saw a cost of $870 million and employed around three thousand people

during construction (Parnell 2019). Six of the top ten solar panel manufacturers in the world based on volume are based in China with JinkoSolar being the largest (EnergySage, 2019).

California has also become the first state to require most new homes and low-rise apartment buildings to be equipped with solar panels beginning in the year 2020 (Bacon, 2018). Although the construction costs are expected to make homes more expensive in an already expensive market, the savings over the lifespan of the solar systems will make up for the initial costs (Bacon, 2018). It is estimated that around 150,000 structures will be built in 2020 that will need to meet the new requirements (Bacon, 2018). The exceptions to the rule are any homes built in well-shaded areas or have too small of roofs to hold the panels (Bacon, 2018). Not only will this be good for reducing carbon emissions, it will also provide jobs in the solar industry and be a model that other states will be able to follow.

Net metering, available in most states and several U.S.A. territories, is one way for those households with solar systems installed to save even more money on utility bills. This billing system works by letting customers send unused electricity from their system back into the power grid for other customers to use and reduce future bills. According to the Solar Energy Industries Association (SEIA), this type of metering helps keep the solar industry in higher demand. Jobs are created for installers, electricians, and manufacturers all within the solar supply chain (https://www.seia.org/initiatives/net-metering).

A large undertaking in making clean energy a possibility for every household is the Tesla Solar Roof. "The Tesla solar roof is a building-integrated photovoltaic (BIPV) product that takes the functionality of solar panels and integrates it into roof shingles" (Richardson, 2019). The biggest obstacle to overcome is the price. Although Elon Musk, Chief Executive Officer for Tesla, believes that his solar roof will last up to thirty years and is durable enough for any

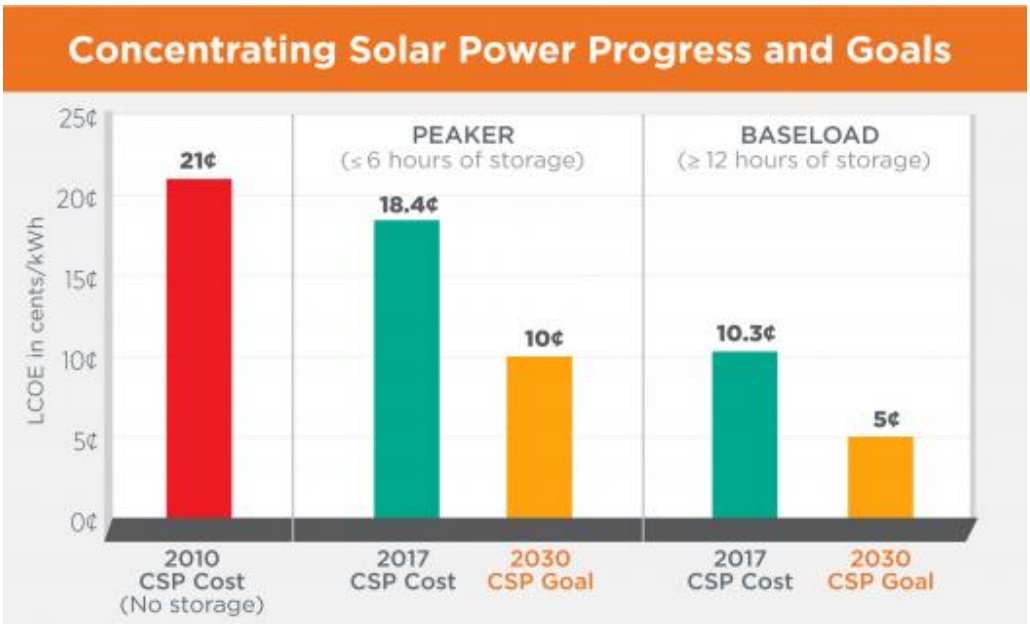
weather conditions, they come with a very high initial investment of somewhere between $21 to $35 per square foot (Richardson, 2019). A traditional shingle roof costs around $5 per square foot (Richardson, 2019). According to Statista, an online provider of market and consumer data, Tesla employed just under 50,000 people at the end of 2018 having started with only several hundred before 2010.

Solar windows filled with quantum dots is a developing technology that could be a few years away from reality. Researchers have been able to put tiny silicon particles in panes of glass that absorb sunlight and emit that light at a different frequency. The light moves through the glass and will eventually be absorbed by solar panels around the edge to be converted into energy. Most of the light is able to pass through the window because of how spread out the quantum dots are. The amount of energy being produced is minimal creating only enough energy to power a cell phone. But the research is promising and could lead to cities replacing normal windows with ones that can produce electricity in the future (Thompson, 2017).

A 2018 study performed by the non-partisan group Environmental Entrepreneurs (E2) finds that there are nearly 3.3 million Americans working in clean energy jobs. The study also finds that around 500,000 people work in renewable energy. Of those, well more than half work in solar energy. Much of the solar industry employment comes from the manufacturing and construction of solar panels and fields. There is an expected 7.1% job growth for 2019 in the renewable energy sector with potential investments from private capital to reach $1 trillion by the year 2030 according to the E2 study (2019).

Concentrating solar power (CSP) is a specific type of renewable solar energy technology that is being developed and utilized around the world for clean energy consumption. The DOE website (2018) explains that “CSP technologies use mirrors to reflect and concentrate sunlight

onto receivers that collect solar energy and convert it to heat." That heat can warm either water for steam or create molten salt that drives a turbine for a generator. The created energy can be stored and used on demand in cloudy conditions or as backup for fossil fuels for a converting or hybrid power plant. Below is a chart taken from the DOE website (2018) showing the progress and goals for CSP operational costs.



(https://www.energy.gov/eere/solar/concentrating-solar-power)

CSP energy costs are expected to drop by around half over the next decade, according to the chart.

According to the International Energy Agency (IEA) (2017), Spain is currently leading the rest of the world when it comes to CSP projects. There are fifty-three current operational projects in Spain. All of these projects took hundreds of workers for construction and currently employ dozens for full-time operations. The U.S.A. is slightly behind Spain with fifty-two CSP projects spread across seven states. California has the majority of those projects being

developed. Overall, there are twenty-three countries on six continents with functioning or developing CSP technology, according to the IEA.

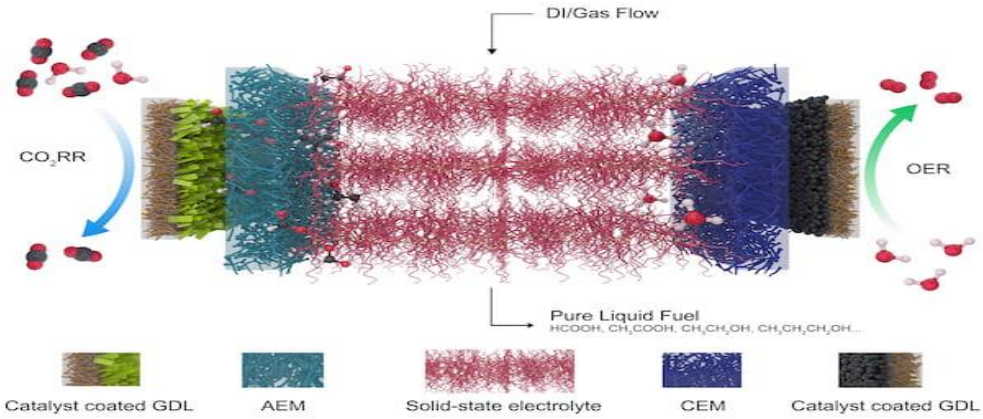
India is taking an approach to solar technologies with more than one function being utilized. Evaporation in the canal system of more than 11,000 miles is a major concern for the country, along with inconsistent power. In order to combat both of these problems, the government began to install solar panels over the canals to help reduce evaporation and provide a more reliable source of electricity. According to Swearingen (2015), only a small portion of the canals have been covered in a pilot project. "If the project is completed, India estimates that 90 million liters of water could be saved from the sun's rays" (Swearingen, 2015).

A New York Times article writes that the Trump administration has decided to put tariffs on imports of solar panels (Swanson & Plumer, 2018). This tariff was put in place to "create jobs in America for Americans" (Swanson & Plumer, 2018). However, the article states that even though this tariff will help domestic production of solar panels, it will have a ripple effect on the rest of the industry, especially since the majority of the jobs in solar energy are in the projects around building solar infrastructure, not manufacturing (Swanson & Plumer, 2018). The article continues to say that 23,000 jobs could be lost in the solar industry within the year as well as billions of dollars of investments being cancelled (Swanson & Plumer, 2018).

Research from a team at Rice University has made significant discoveries in how to make solar panels more efficient by capturing wasted heat into carbon nanotubes (Grossman, 2019). Solar panels currently convert around twenty percent of collected energy into electricity. With this new discovery of nanotube capturing, the theoretical conversion percentage goes to a predicted eighty percent (Grossman, 2019). The technology basically works by absorbing the wasted heat giving the nanotubes control over where the heat photons go. The conversion to

electricity becomes much more efficient when converting from heat to light to electricity (Grossman, 2019). "…even though a proof of concept is a long way from being used in the real world, any further developments in the nanotubes could bolster solar panels in ways we haven't seen yet" (Grossman, 2019).

Rice University has also found a way to turn carbon dioxide (CO2) into a source of liquid fuel (Williams, 2019). The basic idea behind this method is to take CO2 and run it through a catalyst made of bismuth atoms before pumping water through the reactor (Leman, 2019). These reactions result in formic acid, an energy carrier (Williams, 2019). The faster the water flows, the more formic acid is created by weight (Williams, 2019). "With its current reactor, the lab generated formic acid continuously for 100 hours with negligible degradation of the reactor's components, including the nanoscale catalysts" (Williams, 2019). This becomes a closed-loop process since the fuel-cell creates more CO2 and can be immediately recycled (Leman, 2019). The researchers believe this can be replicated on a much larger scale and could potentially be duplicated to produce other types of chemical products such as ethanol and acetic acid (Leman, 2019). Below is a pictorial representation of the reactions that are happening.



(https://news.rice.edu/2019/09/03/rice-reactor-turns-greenhouse-gas-into-pure-liquid-fuel/)

The United Nations (U.N.) has taken a very direct charge when it comes to combating climate change. The U.N. Treaty Collections website (2019) has a list of eighteen environmental treaties. Each treaty is unique in that only a few pertain to most of the countries in the world. Some of them are regional and cater to the specific issues of a particular region. The PCA is a part of the seventh listed treaty (https://treaties.un.org/Pages/CTCTreaties.aspx?id=27&subid=A&clang=_en, 2019).

"The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so" (PCA, 2015). According to the UN website (2016), the PCA was initially signed by one hundred seventy-five countries in April, 2016. It consists of twenty-nine articles mapping out the expectations for each party that has made a commitment to the PCA. The expectations are different for more developed countries with the resources to make more rapid changes to power grids, resource management, and household or industrial emissions. Lesser developed countries should expect assistance from more developed countries in order to adapt more quickly to developing technologies. This type of cooperation between vastly different stages in development amongst different countries is a major key to success for the PCA to achieve the expected goals. Should any party decide to withdraw from the PCA, Article 28 of the agreement allows said party to give notice of withdrawal that will take effect one year after the notice is given. The PCA (2015) states that a notice can be submitted "at any time after three years from the date on which this Agreement has entered into force." Given these parameters and a registered date with the U.N. of November 4, 2016, the earliest any country could withdraw from the PCA is November 4, 2020.

According to Shear (2017), President Donald Trump made the decision within a few months of being in office that the U.S.A. would withdraw from the PCA as soon as it was eligible to do so. The next presidential election in the U.S.A. is November 3, 2020, one day before the U.S.A. could officially withdraw from the PCA. Voters will ultimately be able to decide if the issue of climate change is important enough to elect a new president or if President Trump should be re-elected and continue to undo previous administration's policies on pollution and climate change measures. Shear (2017) continues to say that many corporate, state, local, and world leaders are condemning the decision to withdraw from the PCA, calling it "reckless". The economic impact of this decision to withdraw will be determined with time should the decision stand after the upcoming election. The environmental impact will be negative since standards set during the PCA negotiations will not be met by the U.S.A. as a whole country. All of the Democratic candidates for the 2020 presidential election have pledged to rejoin the PCA with specific targets or a path towards strengthening the commitment (Muyskens & Uhrmacher, 2019).

In a rebuke to President Trump's announcement to withdraw from the PCA, many cities, states, businesses, and universities confirmed support for the agreement. "The group, which calls itself 'America's Pledge,' is led by California Gov. Jerry Brown and former New York City Mayor Michael Bloomberg" (Regan, 2017). The main focus of this group is to help the U.S.A. end its dependency on fossil fuels with coal being the priority. "President Barack Obama, who committed the U.S. to the agreement, had set the goal of reducing U.S. emissions from 2005 levels by up to 28 percent by 2025" (Regan, 2017). The America's Pledge group also works internationally, including with the U.N., to help collect data and give concerned parties detailed

information on paths forward to meet goals set forth in the PCA (https://www.americaspledgeonclimate.com/about/).

The IEA is a group of thirty-eight countries that assesses energy use and forecasts what the future holds for all energy sources including fossil fuels and renewables. These countries account for almost 75% of global energy consumption over half of the energy production (www.iea.org, 2019). According to the IEA website's mission statement (2019), there are four main focuses of the agency: energy security, economic development, environmental awareness, and engagement worldwide. The IEA, which was formed in 1974 during a major energy crisis, achieves their mission through a vast network of international organizations, many forward thinking ideas, and a number of programs aimed at reducing carbon emissions in more developed countries and creating sustainable energy sources for emerging economies. Two of these programs are the Clean Energy Transitions Program (CETP) and the Electric Vehicle Initiative (EVI) (www.iea.org, 2019)

The CETP was launched in November of 2017 and is designed to meet the ambitious goals of the PCA in many developing countries. Those countries include Brazil, China, India, Indonesia, Mexico, and South Africa. The monetary backing of this program comes from more industrialized nations in Europe, Canada, Japan, New Zealand, and Australia. The biggest ideas behind CETP is to ensure that all people have access to electricity, calling it a "basic human necessity" (www.iea.org, 2019). After this is achieved, the transition can begin to renewable sources.

China is perhaps the country in the CETP with the most to gain from transitioning to renewable energy sources. The country has become the world's largest consumer and producer of energy while being highly reliant on coal. They account for nearly 28% of all global carbon

emissions (Clean Energy Transitions Programme (CETP) Annual Report 2018 (2018)). The CETP report (2018) also states that China is "the world's leading investor in renewable energy, with the greatest renewable energy capacity and representing 36% of global projected renewables growth in the medium term (to 2021)." These investments include wind and solar (PV) technologies as well as electric vehicles (EV). China currently has the world's largest installed capacity of wind and solar power (Clean Energy Transitions Programme (CETP) Annual Report, 2018).

The EVI currently has sixteen participating countries including the U.S.A., Canada, Mexico, China, Japan, and other Asian countries along with many EU countries. The focus of the EVI is to increase the number of EVs in cities worldwide to reduce the reliance on fossil fuels (www.iea.org, 2019). EVs will be discussed in more detail in a later section.

Wind power, or wind energy, is another viable alternative to fossil fuels for energy that can be utilized by companies, individuals and local or state governments. Wind turbines work similarly to CSP in that they both create a source of energy that power a generator. The DOE lists two types of wind turbines on its website: horizontal-axis and vertical-axis. The horizontal-axis turbines typically have three blades and must face upwind to properly function. Vertical-axis turbines, however, do not have to adjust to the wind in order operate properly (www.energy.gov, 2019). These turbines can vary in scale from the small, which are used for residential, agricultural, or commercial and industrial consumption, to the very large on wind farms or offshore, which are used by a much larger portion of populations (www.energy.gov, 2019).

A major accomplishment in early wind energy in the U.S.A. happened in the mid-1850s. An inventor named Daniel Halladay "patented the first commercially viable windmill—

Halladay's Self-Governing Windmill" (Halladay's Revolutionary Windmill, 2018). What made his windmill different from all the others before was that it was able to turn on its own to follow the direction of the wind without human intervention (Halladay's Revolutionary Windmill, 2018). This helped lead to better irrigation needed for crops and livestock as well as helping in the expansion of the railroad system with the increasing number of steam engines being used throughout the Midwest (Halladay's Revolutionary Windmill, 2018).

Wind energy was a technology being utilized in the 1970s, along with solar, as an alternative to fossil fuels during the energy crisis. According to the EIA (2019), the federal government provided funding for research and development of wind turbines as well as tax and investment incentives for new projects. These projects led to thousands of turbines being installed in California and expanded to other markets throughout the 1990s and 2000s because of environmental concerns.

The largest offshore wind farm in the world is currently being completed off the coast of England and will produce enough clean energy for one million homes by the year 2020 (Ziady, 2019). According to Ziady (2019), Britain has the "biggest offshore wind market in the world." The U.S.A. will soon have the world's largest wind turbines standing at 853 feet tall off the coasts of Maryland and New Jersey with the first project to be completed by 2022 (Martin, 2019). The projects will bring enough power for around 6 million homes (Martin, 2019). The largest wind farm in the world currently resides in Gansu, China at the Gansu Wind Farm, although it is not being utilized to its fullest potential due to a preferred use of coal by local governments and underdeveloped technologies to transmit electric power to nearby larger cities (Sawe, 2018). The largest land-based wind farm in the U.S.A. is the Alta Wind Energy Centre in

Kern County, California. It was completed in 2014 and utilizes six hundred turbines on about 3200 acres (Sawe, 2018).

Recent reports by the IEA show that offshore wind farms have the potential to create around $1 trillion of investment by the year 2040 and could eventually have the potential to create more than enough power for the world's electricity needs (Higgins, 2019). Governmental policies, falling costs, and technological progress will be the main drivers behind the expansion of this renewable source of energy (Scott, 2019). Floating platforms for wind turbines is one of the new ways that wind power will be utilized in the future. These platforms will be able to go further away from shorelines where it is not feasible to anchor turbines to the ocean floor and there are stronger and more sustained winds (Scott, 2019).

V. Green Manufacturing and Technologies

"Green manufacturing is the renewal of production processes and the establishment of environmentally-friendly operations within the manufacturing field" (Goodwin College, Goodwin College & New England Commission of Higher Education, 2019). Companies are utilizing strategies of reduce, reuse, and recycle to limit their carbon footprint on the earth. One way that manufacturing plants can assure that they are limiting their carbon emissions is by teaming up with the government backed Energy Star program. This program was started by the EPA in 1992 under a section of the CAA (www.energystar.gov, 2019).

> "In 2018, 100 manufacturing plants earned ENERGY STAR certification within the U.S. for their superior energy performance. Together, these U.S. plants reduced their energy bills by more than $400 million, saved more than 70 trillion British thermal units (TBtu) of energy, and achieved broad emissions reductions, including 4.5 million metric tons of

> greenhouse gas emissions. The energy savings are enough to meet the annual energy needs of nearly 440,000 American households" (www.energystar.gov, 2019).

This program is designed to recognize manufacturing plants that meet requirements within their specific industry. Not all manufacturing plants are eligible, and not all eligibilities are the same. Energy Star uses Energy Performance Indicators (EPI) to benchmark criteria for each industry. Examples of eligible industries include certain food processing facilities, automotive manufacturers, petroleum refining, and pharmaceuticals (www.energystar.gov, 2019). Some of these industries in Canada are also able to apply to this program. Examples of the requirements for the program are for facilities to utilize renewable energy sources on site, the use of energy saving products like lightbulbs, and finding ways to consume less water. Companies that strive to be included as an Energy Star plant can find help from experts who can identify areas for improvement and the best way to pay for those improvements (www.energysrat.gov, 2019).

An example of a company that has made many changes toward renewable energy sources and being more environmentally friendly is LEGO. A wind farm built off of the Irish Sea helped the company achieve its goals of being powered one hundred percent by renewable energy ahead of schedule (Richards, 2017). LEGO celebrated this achievement by building the world's largest wind turbine made from LEGOs to help "raise awareness of the importance of renewable energy" (Richards, 2017). This is a company leading by example.

A study done by Rehman and Shrivastava (2013) says that the goal of green manufacturing is "designing and delivering products that minimise negative effects on the environment through their production, use, and disposal." The concept began in the late 1980s in Germany as a way to push global manufacturers to meet environmental regulations in the European market with several definitions from many researchers. The consensus of these

researchers comes to the optimal definition as defined in the 2013 study: green manufacturing "focuses around minimising environmental impact by reducing toxics, waste, pollution, optimising use of raw material, and energy by applying end of life (EOL), cradle to cradle and close loop approach" (Rehman & Shrivastave, 2013). There are many ways that companies can focus their activities in order to be more closely aligned with the definition of green manufacturing. Reducing, reusing, and recycling are the three most well-known activities. Other ways to create a lean, green manufacturing environment involve eliminating human element types of waste. The acronym for these eight types of lean waste is TIMWOODS.

T – Transport – Moving people, products & information
I – Inventory – Storing parts, pieces, documentation ahead of requirements
M – Motion – Bending, turning, reaching, lifting
W – Waiting – For parts, information, instructions, equipment
O – Over production – Making more than is IMMEDIATELY required
O – Over processing – Tighter tolerances or higher grade materials than are necessary
D – Defects – Rework, scrap, incorrect documentation
S – Skills – Under utilizing capabilities, delegating tasks with inadequate training
(https://www.isixsigma.com/dictionary/8-wastes-of-lean/)

Each of these types of waste come from some human source and are easy to eliminate with small changes to a work environment. Attention to detail and understanding the processes with the utilization of Subject Matter Experts (SME) within the work areas are vital for the reduction of lean wastes. Making mistakes is a part of manufacturing. But being able to minimize those mistakes is crucial for companies to save money from having to repeat steps or processes in order to deliver the product expected of customers. Eliminating the TIMWOODS in a production environment also helps with equipment effectiveness. The end result is sustainability and money saved.

Overall Equipment Effectiveness (OEE) is a way that manufacturers measure how well equipment performs based on availability, performance, and quality within their processes (Domingo & Aguado, 2015). Overall Environmental Equipment Effectiveness (OEEE) is a measure to help businesses make decisions based on environmental impacts using OEE with the added element of sustainability (Domingo & Aguado, 2015). Each of these measures gives a real-time glimpse into how well an area or piece of equipment is performing at any given point in time. Businesses can use these measures to help cut waste and reduce machine downtime. Both OEE and OEEE are important for any company looking to work towards being more lean or green in manufacturing.

A study done by Corporate Knights (2018), a Canada based magazine dedicated to researching sustainability and corporate responsibility, releases a top one hundred list of sustainable companies from around the world each year. The Key Process Indicators (KPI) used in this study include the resources being used, waste being produced, emissions rates, taxes, employee pay compared to CEO pay, sustainability, clean revenue, as well as many other factors. Each KPI is weighted with the highest weight going to clean revenue. Companies must have a minimum gross revenue of $1 billion to be eligible for the study. Chr. Hansen ranks as the top sustainable corporation in the world according to the results of the Corporate Knights study. The Danish company's website states "Chr. Hansen is a global bioscience company that develops natural solutions for the food, nutritional, pharmaceutical and agricultural industries." Prologis, Inc., a real estate investment company, is the top company in the U.S.A. on the list at number six. The top manufacturer in the U.S.A. is McCormick & Company, a food and beverage manufacturer, at number thirteen. The list of sustainable corporations is very diverse with many different sectors included from five continents (Staff, 2019).

The idea of EVs has been around since about 1830 with many different types of inventions coming and going, mostly going through lack of interest and investment (Handy, 2014). The early part of the 20th century saw an emergence of EVs with a number of companies having some commercial success in the market. However, several outside factors including the flu pandemic in 1919, a world war, and more reliable gasoline engines took its toll on this early EV market (Handy, 2014). When looking at the modern history of driving, the energy crisis during the 1970's again plays a major role in new technologies. The DOE begins to make funding available for innovations to make more affordable electric cars. In the 1980's, GE and Audi begin work on hybrid cars. But it wasn't until the mid-1990's that hybrid cars would find their way to consumers. The first of these hybrids was the Toyota Prius which debuted in Japan in 1997 (Handy, 2014). Audi, Nissan, Tesla, Ford, Mercedes-Benz, and Chevrolet, among others, have all emerged with hybrid or fully electric cars (Handy, 2014). These EV's can have become more reliable with longer ranges before charging is necessary. Kelley Blue Book (KBB) rates the Tesla Model S as the longest-range electric car of 2019. This model has a range of 370 miles, but comes at a cost of $86,200 and a battery charge time of eleven hours (KBB, 2019). Price and battery charging are the biggest barriers for EV's to be more widely owned. Battery charging stations can be found by using an interactive map through the DOE's website, but most of these stations are concentrated in larger cities and their suburbs. The average price for a midsize, non-electric car is around $25,000 according to KBB. As the technology behind EV's improves and costs decrease, the demand will likely begin to increase.

The E2 report on clean jobs in America finds there were just over a quarter million jobs in the clean vehicle industry in 2018. The majority of those are for hybrid-EVs or EVs. The statistics for these jobs shows clean vehicles account for 13% of all jobs in the motor vehicle

industry, over 15% job growth in 2018 nationwide, and 486,000 additional jobs making parts to make cars more fuel efficient. The report also finds that there are more than one million EVs driving on the nation's roads.

A report from the Brookings Institution in economic studies gives details on the Car Allowance Rebate System (CARS) or "cash for clunkers". This was an Obama administration program to try to help stimulate a struggling economy and put more fuel efficient vehicles on American roads. The idea was for people to trade-in older model vehicles and receive a voucher towards the purchase of a new, more fuel-efficient vehicle. "Nearly 700,000 clunkers were traded in between July 1, 2009 and August 24, 2009 under the program" (Gayer & Parker, 2013). The report concludes that the cost for this program did have some short-term effects with boosted vehicle sales, but overall was not overly effective. The reduction in emissions was minor, and the cost per job created was much higher than other types of stimulus programs. The conclusion from this report does not recommend using the CARS program or something similar as an economic stimulus or a way of reduce carbon emissions (Gayer & Parker, 2013).

The state of California has the highest set of standards for allowable emissions for vehicles. According to the state's Department of Motor Vehicles (DMV) website, for a car to be registered in California it has to be made specifically for the state. All other states follow the EPA guidelines on vehicle emissions which is set to be just over fifty miles per gallon in the model year 2025, according to the Center for Climate Energy Solutions. This standard is for light-duty vehicles, or cars that are used for everyday commuting. The standards seem to align between the EPA and California because of a waiver that the Obama administration gave to the nation's largest state in 2013. The Trump administration is aiming to revoke that waiver and freeze the federal standard for efficiency at thirty-seven miles per gallon (Neuman, 2019). This

is one way that the federal government is hindering climate change efforts. "California was accorded special status in the 1970 Clean Air Act, allowing the state to set its own emissions standards if it could convince federal authorities of the need to do so. Many of California's antipollution measures have been adopted nationally" (Neuman, 2019). This quote is a direct example of how a state government has been able to help the fight against climate change and lead the way for other states to do the same. Thirteen other states have even adopted California's higher standards for vehicle emissions (Neuman, 2019). California governor Gavin Newsom has vowed to contest the Trump administration's decision saying it "could have devastating consequences for our kids' health and the air we breathe, if California were to roll over. But we will not" (Neuman, 2019).

A 2017 study conducted by the International Council of Clean Transportation (ICCT) provides historical data and projections of how improving vehicle emissions effects climate change and human health. According to the study, if the G20 countries involved meet the "world-class" standard for vehicle emission reduction, 60,000 premature deaths in urban areas from health related risks would be prevented by the year 2030. The study does not conclude how many total deaths are preventable, but does make a strong case for implementing the recommended world-class standards for a cleaner atmosphere.

In 2011, China implemented a lottery system to limit how many cars can be purchased each year by its citizens in larger cities such as Beijing (Zhang, 2019). The lottery is for a license plate with only around 100,000 being awarded to individual buyers (Zhang, 2019). "The municipal government will issue 38,000 of those plates to individual buyers of gasoline-powered cars and 54,000 for EVs. It aims to cap the number of locally registered vehicles at below 6.3 million by the end of 2020—in a city of 22 million people" (Zhang, 2019). The idea behind the

system is to lower the amount of pollution by reducing how many cars are allowed and to limit congestion on busy roads in big cities. Vehicles are also only allowed to drive on certain days with even more restrictions to begin in November, 2019 for those who have registered their cars outside city limits (Zhang, 2019). Current restrictions only allow vehicles to drive six days a week while new restrictions for the vehicles registered outside cities will only allow eighty-four driving days per year (Zhang, 2019). These restrictions have hurt the car industry in China but will have a major impact on the health of the people.

South Korea has found an interesting way to charge batteries in EVs without the use of charging stations. A team from the Korea Advanced Institute of Science and Technology successfully installed online electric vehicles (OLEV) with smaller batteries that can be charged by simply driving over a 7.5 mile route in the city of Gumi (Kelion, 2013). The buses that take this route use a technology called Shaped Magnetic Field in Resonance which uses electric cables under the road to create electromagnetic fields. Those magnetic fields are then picked up by coils and converted into electricity (Kelion, 2013). Other OLEV projects can be found in Italy and the Netherlands where buses can make stops and charge without using a plug-in charger (Kelion, 2013). Experts believe this type of innovation could be decades away from being widely used because of the high costs and infrastructure requirements (Kelion, 2013). Below is a picture of how OLEVs work.

(https://www.bbc.com/news/technology-23603751)

The White Plains school district in New York is utilizing a mutually beneficial arrangement with a local electric company. In this arrangement, the electric company, along with some state grant money, helped the schools buy five electric buses. The school district is paying about the same cost as a standard diesel bus. When school is out for the summer, the buses are plugged into the local electric grid for storage of surplus electricity to be used when needed. The idea is to give the utility company a way to reduce cost in upgrading to renewable sources like wind and solar. The final goal is to have electric buses charged from renewable sources of energy (Thompson, 2018).

> "The White Plains deal could be a model for other school districts looking to buy some electric buses. And with school districts buying more buses, the cost per bus will likely go down. There's a good chance we can start seeing this arrangement play out all over the country, and quieter, cleaner, more environmentally friendly buses may become the norm for bringing our nation's children to school" (Thompson, 2018).

Nissan is innovating ways to turn batteries once used in electric cars into street lights in areas with less infrastructure. The batteries may no longer be useful for the EVs that used them, but have been essential to solar-powered street lights in an initiative called "The Reborn Light". Nissan and 4R Energy Corporation partnered with Namie, Japan to help "protect the town from future earthquakes" after being "hit hard by earthquakes and tsunami in 2011" (Thompson, 2018). This is a great example of a company reusing and recycling materials into new products that are carbon-neutral.

Recycling is a major part of many manufacturers success in sustainability and environmental health. But the amount of materials being recycled is not as high as it needs to be to help solve the pollution issues seen in the oceans. It is being predicted that "there will be more plastic in the oceans than there are fish by 2050" (Cortina, 2018). The top companies in an environmental ranking done by JUST Capital are Accenture, Intel, Estee Lauder, Eaton, and Texas Instruments (Cortina, 2018). The rankings are based on carbon emissions, the amount of waste sent to landfills, recycling materials, along with other key metrics (Cortina, 2018). The listed companies are not just making an impact at single sites within their network, but at most or all sites in operation around the world (Cortina, 2018). This is important because of the major impact that these environmental activities can help to slow climate change and set a precedent for other companies to follow.

The EPA lists these seven benefits of recycling:

- Reduces the amount of waste sent to landfills and incinerators
- Conserves natural resources such as timber, water and minerals
- Increases economic security by tapping a domestic source of materials
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Supports American manufacturing and conserves valuable resources
- Helps create jobs in the recycling and manufacturing industries in the United States (https://www.epa.gov/recycle/recycling-basics).

The EPA also estimates that recycling employees around 757,000 people with an economic benefit of $36.6 billion in wages and $6.7 billion in tax revenues (https://www.epa.gov/sites/production/files/2017-05/documents/final_2016_rei_report.pdf).

TerraCycle, headquartered globally in Trenton, New Jersey, is a company making a major difference in how items can be recycled. Their mission is to make all waste recyclable while making charitable donations around the world. The company was founded in 2001 by Tom Szaky and is now operating in more than twenty countries with over 200 million people collecting waste and nearly 8 billion units of waste having been recycled. The company has around three hundred employees and has won over two hundred awards for social entrepreneurship and sustainable business from around the globe. The company has paired with many major brands to make it easier for individuals, companies, and communities to collect and drop-off or mail many types of difficult to recycle materials to processing facilities. There are a number of items the company will take for free that can include things like beauty product bottles, detergent bottles, plastic toys, electronics, and dead batteries among many other things. An interactive map on the TerraCycle website helps with finding local recycling centers for any typical recyclable materials such as plastics, aluminum, glass, and paper. Many other items accepted by the company require the purchase of different size boxes to be filled and shipped to recycling centers. All information regarding the company can be found on their website at https://www.terracycle.com/en-US/.

Sustainable Recycling Industries (SRI) is a Swiss funded group that is utilized to help developing countries learn how to sustainably recycle electronic waste to avoid environmental and health hazards (https://www.sustainable-recycling.org/about-sri/). India is one of those countries and has developed the "GreenCo Rating for E-Waste Recyclers". According to the Confederation of Indian Industry (CII), this rating system, which was piloted in June of 2018, is meant to help develop best practices and knowledge sharing with e-waste recyclers across the country. There are four rating levels (platinum, gold, silver, and certified) that are obtained by

receiving points within set parameters; general aspects, material flow management, supply chain management, and environmental management. Each of these parameters are broken down and include factors such as worker safety and conditions, cleanliness, clean water, standard operating procedures (SOP), monitoring systems, efficiency, and many other factors that can earn points towards higher ratings. Recycling companies in India who wish to participate can contact the governing body to fill out a questionnaire and register for training programs. The governing body will then come to the facility and give the company a final rating along with ways to improve towards best practices. The rating is only valid for three years. A company must reapply to receive a new rating, but can also ask for additional inspections should improvements be made in order to have a higher rating (https://www.sustainable-recycling.org/wp-content/uploads/2018/10/GreenCo_Recyclers_Pilot.pdf).

Carbon capture and storage (CCS) is an important strategy when combating climate change, though it has been politically divisive as well as expensive. The idea of CCS is to capture CO2 in one of three ways: post-combustion, pre-combustion, and oxygen-rich combustion. Post-combustion is designed "to capture CO2 from the flue gas generated after the fuel is burned in the air" (Liu, Ren, Shen, Liu, & Li, 2019). Pre-combustion is a series of chemical reactions in specific conditions of temperature, pressure, and steam in order to separate the chemicals in fossil fuels to create energy and sequester CO2 for storage. Oxygen-rich combustion is another series of chemical reactions using pure oxygen and water to create energy before capturing CO2 (Liu, Ren, Shen, Liu, & Li, 2019). There are also CCS techniques that use chemical reactions to separate CO2 molecules. These three methods are the chemical absorption method, solid absorption method, and the membrane separation method. The chemical absorption method uses alcohol amines such as ammonia, ethanolamine, diethanolamine, and

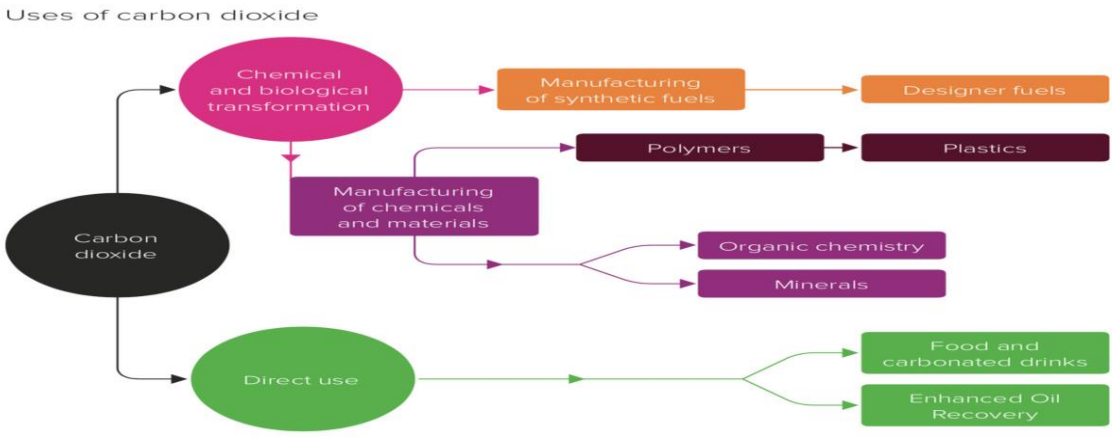
methylethanolomine, among others, to absorb CO2 and be stored in liquid storage tanks. The solid absorption method is similar to the pre-combustion method in that it uses chemical reactions in specific pressure and temperature conditions. The membrane separation method "refers to the selective separation of CO2 from gas through membrane under certain condition" (Liu, Ren, Shen, Liu, & Li, 2019). After the CO2 has been captured, it must be treated further and stored in a permanent manner. Three ways for storage are geological, marine, and chemical. Geological storage is putting CO2 in open reservoirs or cavities that have been depleted of other natural resources or utilizing natural rock formations such as basalt. Ocean storage utilizes the depth, high pressure, and frigid temperatures to send CO2 through pipes deep into specified areas of the ocean for long-term storage. Chemical storages utilizes reactions between metals and CO2 to form inorganic carbonate to be permanently sealed. This method is being researched as it "requires large amounts of energy, minerals and proper disposal of waste" (Liu, Ren, Shen, Liu, & Li, 2019).

Engineers in Iceland have teamed with engineers from France and the U.S.A. to utilize a method of CCS technology that is unique to the island because of the natural resources that surround them. Although the country's carbon emissions have increased in recent years, they have developed a way to turn those emissions into mineral solids thousands of feet below the surface of the earth through a method they call CarbFix (Daniels, 2019). The CO2 that comes from the power plant's steam is dissolved into large amounts of water, sent to nearby wells, and then injected into basalt rock 3,300 feet below ground (Daniels, 2019). The "CO2 becomes mineralized and safely stays underground forever" (Daniels, 2019). This process works because of the uniqueness of the geothermal energy consumption, a seemingly infinite water source, and basalt rock from an ancient volcano. This process has reduced the power plants emission by one

third and is able to be replicated in other areas with massive desalinated water sources and basalt rock (Daniels, 2019). The cost for this carbon capture process is only about $25 per ton (Richard, 2019). The drawbacks are that there is no process yet developed for use with salt water, and the power plant is near a volcano that always has a potential for eruption. It also takes around twenty-five tons of water for every ton of CO2 (Daniels, 2019). Another climate group called Climeworks has teamed up with CarbFix to retrofit power plants in Iceland to not only capture CO2 being produced, but also take CO2 out of ambient air creating the first negative emissions power plant (Thompson, 2017). "Climeworks uses some of that plant's waste heat to run their own carbon capture tech, pulling carbon dioxide directly out of the air and feeding it into the existing CarbFix infrastructure" (Thompson, 2017).

Another method for CCS is pyrolytic carbon capture and storage (PyCCS). "If biomass is pyrolyzed, the organic carbon is converted into solid (biochar), liquid (bio-oil), and gaseous (permanent pyrogas) carbonaceous products" (Schmidt, Hagemann, Werner, Gerten, Lucht, & Kammann, 2018). Biochar has seen many different uses including in agriculture for enriching soil or manure treatment, animal feed ingredients, and composting. Bio-oil has applications in bioplastics, asphalt, building materials, wood preservative, crop protection, feed additive, and plant growth enhancer. The gaseous carbon is much more difficult to find uses without having further chemical separation to create pure CO2, which is much easier to store permanently. The PyCCS is a newer technology that has yet to be tested on a large scale and would need further development before it could be widely used. There are lots of promising early results with many applications that not only reduce carbon in the atmosphere, but they also help in other industries such as agriculture (Schmidt, Hagemann, Werner, Gerten, Lucht, &Kammann, 2018).

Carbon capture and utilization (CCU) takes the CO2 from CCS and finds viable options for commercial use beyond what has been previously discussed. "By some estimates, it's a potentially $1 trillion market by 2030" (Roberts, 2019). The idea that is if the amount and price of CO2 captured from the air became competitive with CO2 from the earth, industries could utilize this new source and reduce the amount of CO2 in the atmosphere as well as new emissions from ground sources. This is not a method to replace CCS, but to supplement the progress that has already been made since the amount of carbon emitted is simply a massive amount in comparison (Roberts, 2019). Direct air capture (DAC) is when CO2 is removed from the ambient air that surrounds us, not from a more concentrated flue gas. Since CO2 is concentrated equally within the atmosphere, it does not matter where this technology is utilized. The only prohibitive piece is cost. As long as there is a willingness to invest in DAC, it could prove to be "the most promising negative-emissions technology in the long term" (Roberts, 2019). But as long as there is no real economic benefit in the short-term and no political will to invest in such technologies, it will likely remain expensive and less utilized when compared to other ways of reducing emissions.



(https://www.vox.com/energy-and-environment/2019/9/4/20829431/climate-change-carbon-capture-utilization-sequestration-ccu-ccs)

The International Organization for Standardization (ISO) is an organization that helps businesses develop sustainability goals with regards to the environment while also meeting business needs. The ISO began in 1947 to create and coordinate international standards in technology and manufacturing (www.iso.org, 2019). According to the ISO website, the non-governmental organization consists of 164 member bodies with each being in one of three categories: member bodies, correspondent members, and subscriber members. These categories come with different levels of access and influence. To become a member or upgrade a membership to the ISO, annual membership fees must be paid on time, all obligations of an ISO member must be met, all ISO rules and decisions must be followed, the organization joining must represent standardization in the joining member's country and that country must be recognized by the UN (ISO Membership Manual, 2015).

The ISO plays a major part in the fifteen year sustainable development plan set forth by the UN. There are seventeen goals aiming to be met by the year 2030. Each of these goals has a specific purpose, and all can be achieved in tandem. According to the UN website (2015) on sustainable development, "the Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice."

Goal seven for sustainable development is focused on how energy is created for everyday use. According to the UN, 13% of the world's population does not have access to modern electricity with 3 billion people relying on non-renewable sources for cooking and heating. The targets for reaching goal seven by 2030 include: increasing access to renewable energy, making it more affordable and reliable, increasing research of renewable energy while improving

international cooperation, and expanding infrastructure and upgrading technology, particularly in developing areas of the world (https://www.unorg/sustainabledevelopment/energy/, 2015). Goal eight is about economic growth. This goal has a broad range of targets that include closing pay gaps, ending modern slavery, increasing access to better paying jobs, and increasing productivity. The main idea is to create better standards of living for all people on Earth by simply making it easier to get an education and earn living wages. Half of the world's population earns around the equivalent of 2 US dollars per day with 470 million new jobs needed for the labor market by the year 2030 (https://www.un.org/sustainabledevelopment/economic-growth/, 2015).

The thirteenth goal for the UN's sustainable development plan is about climate action. This is an important goal to achieve because of the drastic effects climate change has on world economies and ecosystems. The biggest threats of climate change come as rising sea levels, stronger and more frequent storms, and decreasing sources of food. The UN states that "for each 1 degree of temperature increase, grain yields decline by about 5 per cent. Maize, wheat and other major crops have experienced significant yield reductions at the global level of 40 megatons per year between 1981 and 2002 due to a warmer climate" (https://www.un.org/sustainabledevelopment/climate-change/). These changes are becoming a danger to all life, especially those living in extreme poverty around the world. The biggest targets set forth in the sustainable development goals are to educate people on the importance of mitigating climate change, have more developed countries work with and fund lesser developed countries, and make climate change a priority in national policies. The UN believes accelerating the implementation of these goals will help to limit rising temperatures to 1.5ºC. This will not

only save lives and ecosystems, but it will make a "more sustainable and equitable society" (https://www.un.org/sustainabledevelopment/climate-change/).

Climate change philanthropy is a relatively new type of concept in which individuals and businesses can help fund research and projects on climate action. The Climate Group, founded in 2004, is one organization that works with businesses and governments to meet sustainability goals. According to their website, the Climate Group's mission is "Accelerating climate action." Their goal aligns directly with the UN and PCA with "a world of no more than 1.5°C of global warming and greater prosperity for all" (https://www.theclimategroup.org/about). The group has a total of around 123 state, regional, and national government members involved in the Under2 Coalition. This group aims to help governments set goals in a 2050 pathway to help meet global emissions standards. There are six key components to a 2050 pathway that include creating a vision with long-term targets, receiving input from all stakeholders within the society, integrating government agencies in the involvement of policies and actions, projecting the outcome of actions taken, and reviewing and assessing actions that have been taken (2050 Pathways, 2019).

The RE100 is a group of 204 companies that have made the commitment to be 100% renewable or carbon neutral in their day to day operations. This group of companies is partnered with The Climate Group. These are large, very recognizable global businesses with multiple locations around the world. They represent a vast array of industries including banking, pharmaceuticals, food manufacturing, airlines, social networks, ridesharing, retail stores, and consumer goods among many others. According to a 2018 study put out by a partnership of The Climate Group and Capgemini Invent, companies who commit to 100% renewable sources of energy are not only helping the environment, they are also more profitable when compared to companies not involved with the RE100. The study involved around 3500 companies with

revenues of at least $1 billion. The conclusions show in every sector, net profit margins and earnings before income and taxes (EBIT) are all higher with those companies in the RE100 (Andrillon, Roure, Comby, Alarcon, & Petersen, 2018). This data makes for a strong business case to any company in any industry making decisions on energy consumption for renewable energy.

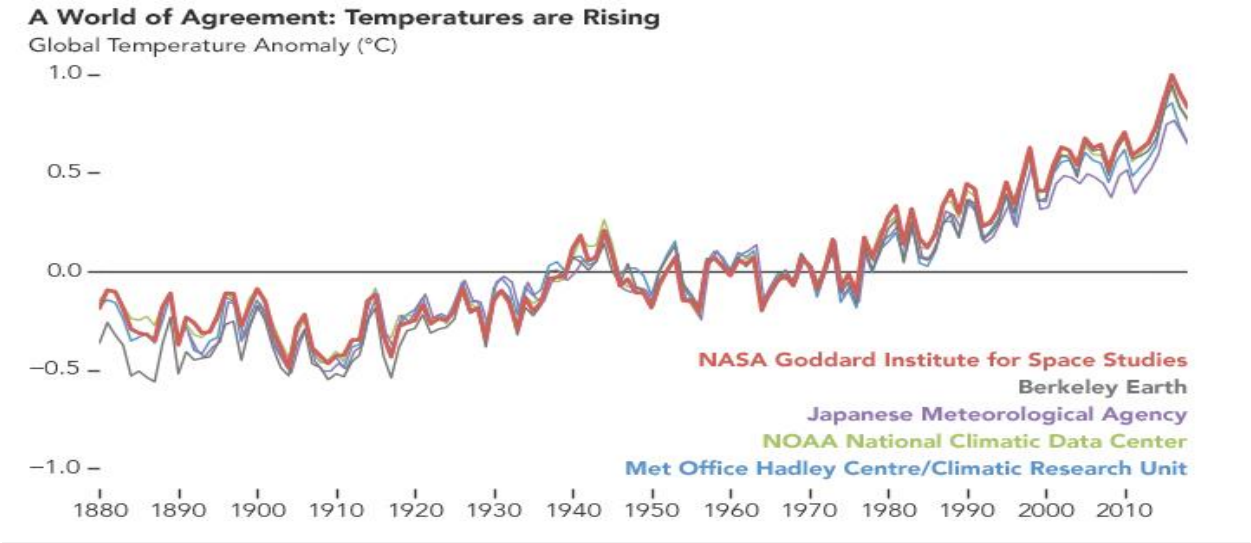
The Under2 Coalition also works with struggling and underdeveloped regions through the Future Fund, which began in 2016 (Future Fund Report, 2018). The Future Fund receives financial support from a few governments including Canada, Scotland, and Wales though Tim Ash Vie, Director of the Under2 Coalition, encourages "all governments, as well as philanthropic and individual donors, to support those with fewer resources to step up their climate action by contributing to the Future Fund" (Future Fund Report, 2018). The main way this fund works is to enable regions with similar issues, such as droughts and fires or new ways to manage economic growth while limiting or lowering greenhouse gas emissions, to get together and share ideas and success stories to help lesser developed areas. The amount of income received in 2018 was a relatively small amount at just over $150,000 from government donations by Quebec, Scotland, and Wales (Future Fund Report, 2018). This money is allocated to three main priorities: capacity building and knowledge exchange, expanding the network and active engagement, and management and scaling of the future fund (Future Fund Report, 2018). With a limited budget, there were only two projects and three secondments that received a maximum funding award of $25,000 (Future Fund Report, 2018). Should the Future Fund receive more income, more projects could be funded.

VI. The Green New Deal

The Green New Deal (GND) is a non-binding congressional resolution that is designed to take "drastic measures to cut carbon emissions across the economy, from electricity generation to transportation to agriculture. In the process, it aims to create jobs and boost the economy" (Kurtzleben, 2019). This type of massive change would affect every person in the U.S.A. because it aims to completely eliminate the use of fossil fuels, which means more EVs, healthier foods, higher quality of health, and a number of expected economic benefits with the creation of clean energy jobs (Kurtzleben, 2019). House of Representatives member Alexandria Ocasio-Cortez (AOC) and Senator Edward J. Markey have been the main legislators behind the newest version of the GND. But it is not as new as it sounds. In 2008, an article in Newsweek describes the same type of deal for a global economy that was just coming out of a recession. The concern was over high and growing unemployment in nearly every region of the world. There was also a presidential campaign in the U.S.A. between Democratic Senator Barack Obama and Republican Senator John McCain, both of whom were advocating for green economies internationally. The article continues that Obama pledged to "'strategically invest $150 billion over 10 years' in a 'clean energy economy' that will 'help the private sector create 5 million new green jobs, good jobs that cannot be outsourced'" (Dickey, 2008). The thought in 2008 was the same as it is today; invest heavily in green technology to reduce carbon emissions and slow the effects of climate change all while boosting economic growth at the same time. The current estimated cost to implement this plan is in the trillions of dollars, especially when considering the desire for universal health care and a job guarantee (Kurtzleben, 2019). AOC, Senator Markey, and other progressive Democratic lawmakers have been unable to gain traction in building broad support for the GND. "The Green New Deal bill does have some 60 co-sponsors, but when it comes to political pressure, that constitutes little, a mere 14% of the entire House and a still small 25% of

the Democratic caucus" (Ezrati, 2019). There is simply not enough political will or capital to invest in this type of deal from Republicans or Democrats.

There is support for the GND from most of the Democratic nominees for president. Some of the candidates have ambitions towards net zero carbon emissions, but would prefer to take a different approach that would not include certain things like Medicare-for-all or paid vacations and affordable housing. They instead would keep CO2 emissions as a separate goal from healthcare, wages, and housing. The broad goal of all of the candidates is to reduce CO2 emissions as soon as possible and have a nation with less dependence on fossil fuels and more renewable energy sources (Muyskens & Uhrmacher, 2019). This is an obvious contrast to the current administration who has repeatedly rolled-back environmental rules and has claimed on Twitter that climate change "was created by and for the Chinese in order to make U.S. manufacturing non-competitive" (Matthews, 2017). As of 2017, there have been over one hundred times that President Trump has been a skeptic of climate change via Twitter (Matthews, 2017). Climate scientists have come to an overwhelming consensus at 97% that climate change is happening and is cause by humans (https://climate.nasa.gov/faq/17/do-scientists-agree-on-climate-change/). Below is a chart showing how world scientific researchers agree on rising temperatures (https://climate.nasa.gov/system/internal_resources/details/original/1736_world-of-agreement-2018.jpg).



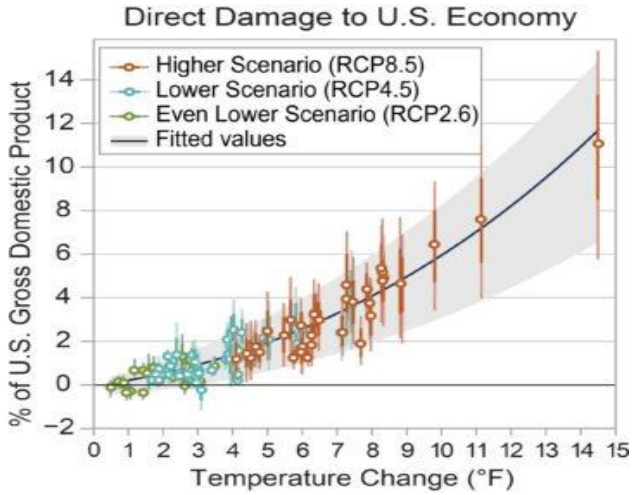
The cost of the GND could be a twofold question; how much money would it take to implement the legislation, and what is the cost of doing nothing towards the legislation? The first question will be the most difficult to answer because there simply has not been enough detailed information given from AOC, and no committees have been formed to help shape what specific proposals may cost (Ezrati, 2019). But there are several estimates to how high the price tag may be for such an ambitious goal.

The main goals of the GND that include 100% renewable energy nationwide, a smart power grid nationwide, CCS technology, guaranteed "living wage" jobs to every American, and a universal health care system are estimated to be $25 trillion over a ten year period. This estimate is based on what details are known about the GND. 2018 budget spending for the government was around $4.5 trillion. That would mean spending would increase by over fifty percent from previous budgets (Ezrati, 2019). This is not an all-inclusive price tag. Republicans have claimed that this deal could cost near $93 trillion based on estimates from the right-leaning research of the American Action Forum (AAF). This number can be misleading because the estimate was a range of $51-$93 trillion specific aspects of the policy without taking economic

benefit into consideration (McDonald, 2019). Other experts say there is no real way to calculate the cost of such policy because there are no real policy proposals, yet. "The Green New Deal… is a set of ambitions, not policies, and how much things cost will depend on what the policies are" (McDonald, 2019). According to McDonald (2019), when legislation includes policy proposals, the Congressional Budget Office (CBO) can score those proposals to give a better idea of the real cost toward a federal budget. Some economists believe that a ten year timeline is unrealistic because of the financial burden on the overall economy. But there is a promising outlook from an economist at the University of Massachusetts Amherst in getting to a net-zero emissions goal by 2050 with only having to spend $18 trillion, or about two percent of gross domestic product (GDP), over the span of the next thirty years (McDonald, 2019). In this thirty year scenario, the economy can grow in the green technology sector without having major impacts to the utility bills of consumers (McDonald, 2019). An economist from Colorado State University agrees about the unrealistic timeline of ten years but does believe that investing around five percent of GDP, or just over $1 trillion over the next few years into green technology could "push us on a path to clean energy, and a path that permanently lowers carbon emissions" (McDonald, 2019).

The direct damage to the economy of the U.S.A. if no action is taken on the GND is also a mostly unknown factor. But there are projections in a study by environmental economists at the University of Chicago that by the year 2090, the economy could see as high as a ten percent loss in GDP should the Earth's temperature rise to an astronomical fifteen degrees above pre-industrial levels (McDonald, 2019). This is an unlikely scenario since there are massive efforts worldwide to curb climate change. "The study found that for every 1.8 degree Fahrenheit increase in global mean temperature, the damages would amount to about 1.2 percent of GDP"

(McDonald, 2019). There are a number of factors that are being taken into consideration when economists make these model predictions. They include, but are not limited to, agriculture, crime, energy, human mortality, and labor (McDonald, 2019). Many other factors have not been taken into consideration because there has not been enough research. Entire communities of people can also adapt to changing weather patterns and create new ways to influence GDP which could skew projections (McDonald, 2019). Below is a chart showing scenarios related to how changes in temperature effect the economy of the U.S.A. over time.



(https://www.factcheck.org/2019/03/how-much-will-the-green-new-deal-cost/)

Some reports project that the monetary impact of climate change nearly $300 billion by the end of the century from heat related deaths, sea level rise, and damage to infrastructure (Davenport & Pierre-Louis, 2018). There will also be trade disruptions with areas of the world that companies depend upon for cheap labor due to more frequent flooding and other natural disasters. This can cause prices of goods manufactured overseas to increase in the U.S.A. because of scarcity in the supply and demand chain (Davenport & Pierre-Louis, 2018). Agriculture is beginning to see major damage to much of the Midwest with much larger amounts of rain and extreme heat.

There is expected to be declines in livestock health, crop yields, and quality of products (Davenport & Pierre-Louis, 2018). "By 2050, the scientists forecast, changes in rainfall and hotter temperatures will reduce the agricultural productivity of the Midwest to levels last seen in the 1980s" (Davenport & Pierre-Louis, 2018).

The environmental factor of making no progress towards the GND are projected to be just as severe. A report issued by the Intergovernmental Panel on Climate Change (IPCC) gives details of how the environment is being impacted by human causes. Extreme weather including droughts, hurricanes, wildfires, rains causing floods, and more frigid winters are occurring at a higher frequency and have become more dangerous. Sea levels are continuing to rise with the melting of icebergs and ice caps causing small islands and low coastal areas to be at higher risk of flooding or are already underwater. The ocean is absorbing a large amount of CO2 resulting on acidification putting marine organisms and ecosystems at risk (Special Report: Global Warming of 1.5ºC, 2018). This same report says that a mass die-off of coral reefs could happen as soon as the year 2040. These trends will continue until action is taken by governments to control the amount of carbon emissions and attempt to eliminate CO2 as much as possible. The damage is estimated to come at a cost of $54 trillion if the goals are not met (Davenport, 2018).

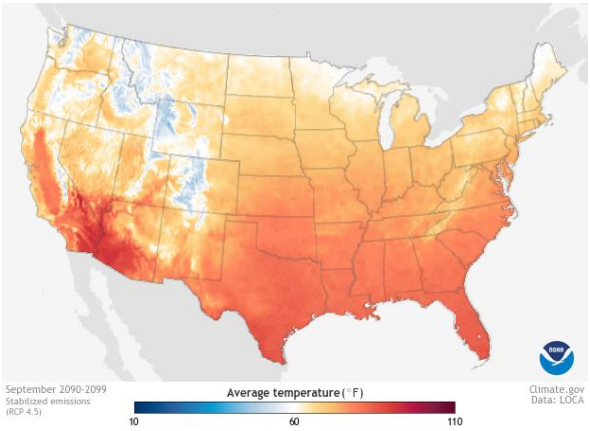
> "To prevent 2.7 degrees of warming, the report said, greenhouse pollution must be reduced by 45 percent from 2010 levels by 2030, and 100 percent by 2050. It also found that, by 2050, use of coal as an electricity source would have to drop from nearly 40 percent today to between 1 and 7 percent. Renewable energy such as wind and solar, which make up about 20 percent of the electricity mix today, would have to increase to as much as 67 percent" (Davenport, 2018).

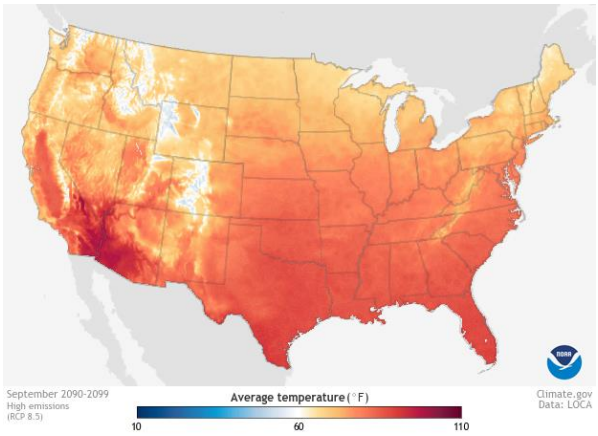
Political instability around the world is another concern brought to attention by top military officials. The Department of Defense released a report titled "National Security Implications of Climate-Related Risks and a Changing Climate" in 2015 that found risks involving poor living conditions, low levels of human security in poverty stricken areas, and governments that will not be able to meet the needs of populations. The report found that the four general areas of risk all stem from weather related events such as droughts, floods, higher temperatures, more frequent and severe weather events, rising sea levels with higher temperatures, and an ever decreasing amount of Arctic ice. All of these factors lead to more dangerous search and rescue efforts as well as higher numbers of displaced people. Mitigation efforts have included building infrastructure to handle emergency situations and providing training and equipment for faster, more effective responses. Sharing best practices is also an important factor to these efforts. These security risks are not isolated to any particular region or country. The report concludes that most parts of the world, including parts of the U.S.A. could see the negative effects of climate change. A link to this report can be found on the DOD website (https://www.defense.gov/Newsroom/News/Article/Article/612710/).

Sea-level rising could be a much greater risk than once thought to many East Asian and Middle Eastern cities if actions are not taken with urgency. New studies show that major cities will begin to be covered by water during high-tide as early as 2050. These cities include, Ho Chi Minh City, Shanghai, Mumbai, Alexandria, and Basra (Lu & Flavelle, 2019). All of them are coastal cities with ports and all of them play an important role in their country's economies. Potentially hundreds of millions of people will be forced to move more inland and find new employment. Many farmers will be included in that figure, which could make food sources

scarce. There is also fear that the vast amounts of people moving could result in military conflicts and terrorism (Lu & Flavelle, 2019).

Predicting what will happen to economies and ecosystems as the Earth's temperature continues to rise is a very difficult task. There are many variables that must be considered. The National Oceanic and Atmospheric Administration (NOAA) has some insight on what the future may look like based on periods in the past. 55 million years ago, during the Paleocene-Eocene Thermal Maximum, "CO_2 in the atmosphere rose to 2000 parts per million within the span of 10,000 years. Subsequently, Earth's average global temperature rose by approximately 11 degrees Fahrenheit (6 degrees Celsius). The result of this rapid temperature increase wiped out plants and animals that couldn't adapt to the new conditions" (https://www.climate.gov/maps-data/primer/future-climate). Should this type of event happen again in a much shorter time period, plants and animals will have to find new ways to adapt or they will become extinct. Current predictions are well under the 11 degrees warming seen millions of years ago. However, governments, businesses, and all humans on Earth will have to make decisions on how to react to the risks involved with warming global temperatures. Below are two maps comparing average temperatures for the U.S.A. with stabilized emissions and high emissions near the year 2100.





(https://www.climate.gov/maps-data/data-snapshots/averagetemp-decade-LOCA-rcp85-2090-09-00?theme=Projections)

These maps show significant amounts of warming in all forty-eight contiguous states.

VII. Conclusion

From the Industrial Revolution to modern breakthroughs in technology, humans have developed ways of increasing productivity and making life more manageable for the masses. Government regulations and legislations have played a major role in how companies are able to run businesses. They have helped and hurt certain industries throughout history based on economic and environmental needs and ideals at the time. The New Deal helped the U.S.A. come out of the Great Depression while the Green New Deal aims to help the U.S.A. and the world curb climate change while also creating meaningful jobs to the economy. Though there is not much promise of the GND passing policies in the near-term, the conversation on how to handle climate change and the costs have begun to take shape. Policies that aim to lower greenhouse gases hurt fossil fuel industries while legislation that regulates pollution make it more expensive for companies to get rid of waste. Governments around the world have played an integral role in setting the rules on pollution. Nearly every country on Earth has made commitments to cutting greenhouse gas emissions by joining the PCA.

Companies around the globe have taken major steps to make Earth a more sustainable place to live by making commitments to using renewable energy by certain target dates. They are finding ways to reduce, reuse, and recycle as many resources as possible. Green technologies are becoming cheaper and are being utilized by American companies to become Energy Star rated. Utilities companies are beginning to find value in investing in solar and wind farms.

Entrepreneurs and researchers are finding new ways to utilize energy created from the sun so businesses and individuals can take advantage of lower energy costs. Wind energy has the potential to power the entire planet. Climate change philanthropists are able to invest and help interested parties make the transition to renewable energy sources. There are major initiatives through sustainability goals to make life more equitable worldwide, not just the most industrialized and wealthy nations.

Electric vehicles have become a viable option in most areas of the U.S.A. because of the falling costs of EVs and the growing infrastructure to support them. More countries in the world are finding ways to prevent people from driving vehicles powered by gasoline through charging fees to drive in certain areas, creating days of little to no driving within major parts of cities, and lottery systems that determine who can buy new vehicles. The results of these initiatives have shown many positive impacts to overall pollution and the health of the population.

In comparing the U.S.A. to the rest of the world on green technology and climate change initiatives, it is clear that the world is currently winning overall. There were many decades in which the U.S.A. was able to lead the charge on pollution, but the present government seems to not see as much urgency in the matter. The focus has been on loosening regulations so businesses can grow and regulate without government interference. Many countries around the world are seeing more dire effects of climate change and have taken actions to slow these effects. However, there are cities, states, entrepreneurs, and businesses who are pushing back and making their own climate change strategies. Scientific research proves and experts agree that it is important to take measures to slow the warming of planet Earth to under 2 degrees Celsius for the viability of life. If the U.S.A. is going to win in the global economy, the future is green technology and manufacturing.

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